# Poly(*p*-phenylene terephthalamide) Film as a Matrix Film for Electrochromic $V_2O_5$ and the Improvement of the ECD Properties

Jun Yano, Tomoyuki Hirayama[1], Sumio Yamasaki[1] and Suzuko Yamazaki[2]

Department of Engineering, University of East Asia, Ichinomiyagakuencho 2-1, Shimonoseki, Yamaguchi 751-8503, Japan

[1]Faculty of Engineering, Kyushu Sangyo University, Matsukadai 2-3-1, Higashi-Ku, Fukuoka 813-8503, Japan

[2]Faculty of Science, Yamaguchi University, Yoshida 1677-1, Yamaguchi, Yamaguchi 753-8512, Japan

Among inorganic ECD materials, vanadium pentoxide ($V_2O_5$) films have attracted attention for use in multicolored ECDs [1]. The $V_2O_5$ films readily deteriorate and exhibit no electrochromism when they are subject to over-oxidation or over-reduction. Moreover, without the over-oxidation or over-reduction, the films peel off the electrode substrates after about 1500 color change cycles [2]. To enhance the durability, we have used an aramid resin, poly (*p*-phenylene terephtalamide) (PPTA), as a matrix film and prepared the PPTA-$V_2O_5$ composite film.

The PPTA film was obtained on an indium-tin oxide (ITO) [3]. On the ITO electrode and the PPTA film-coated ITO electrode, $V_2O_5$ was electrodeposited from aqueous electrolyte solution containing $VOSO_4$ until the passed charge reached 2.0 C cm$^{-2}$. The cyclic voltammograms of the obtained the $V_2O_5$ and PPTA-$V_2O_5$ composite films were measured, and both voltammograms were almost the same shape. Significantly, however, the absorption spectra were different from each other (Figs. 1 and 2). The absorbance ranging from 600 to 900 nm changes more remarkably in the PPTA-$V_2O_5$ film than in the $V_2O_5$ film. The PPTA-$V_2O_5$ film exhibits higher contrast ratio.

In the reduced state of the PPTA-$V_2O_5$ film (Fig. 2 (a)), the absorbance peak is evident at about 800 nm, and the film becomes green. On the other hand, the $V_2O_5$ film is bluish green at -0.6 V. The XPS signal peak of V(2p) of the PPTA-$V_2O_5$ film was 1.5 eV lower than that of the $V_2O_5$ film, implying that the lower valency of vanadium, V (III) as well as V(IV), exists in the PPTA-$V_2O_5$ film. The PPTA-$V_2O_5$ film showed no blue color due to the relatively small amount of V(V), compared with V (III) and V(IV). This is probably due to the simultaneous presence of carbonyl and amino groups on the polymeric backbone whose lone pair electrons are available to coordinate with V(V). In addition, the electronic coordination of PPTA prevented $V_2O_5$ from degrading and from peeling off the electrode substrate during the repetitive color changes under anodic and cathodic polarizations. No color change took place after 200 repetitions for the $V_2O_5$ film, while a color change was obtained even after 5000 repetition for the PPTA-$V_2O_5$ film.

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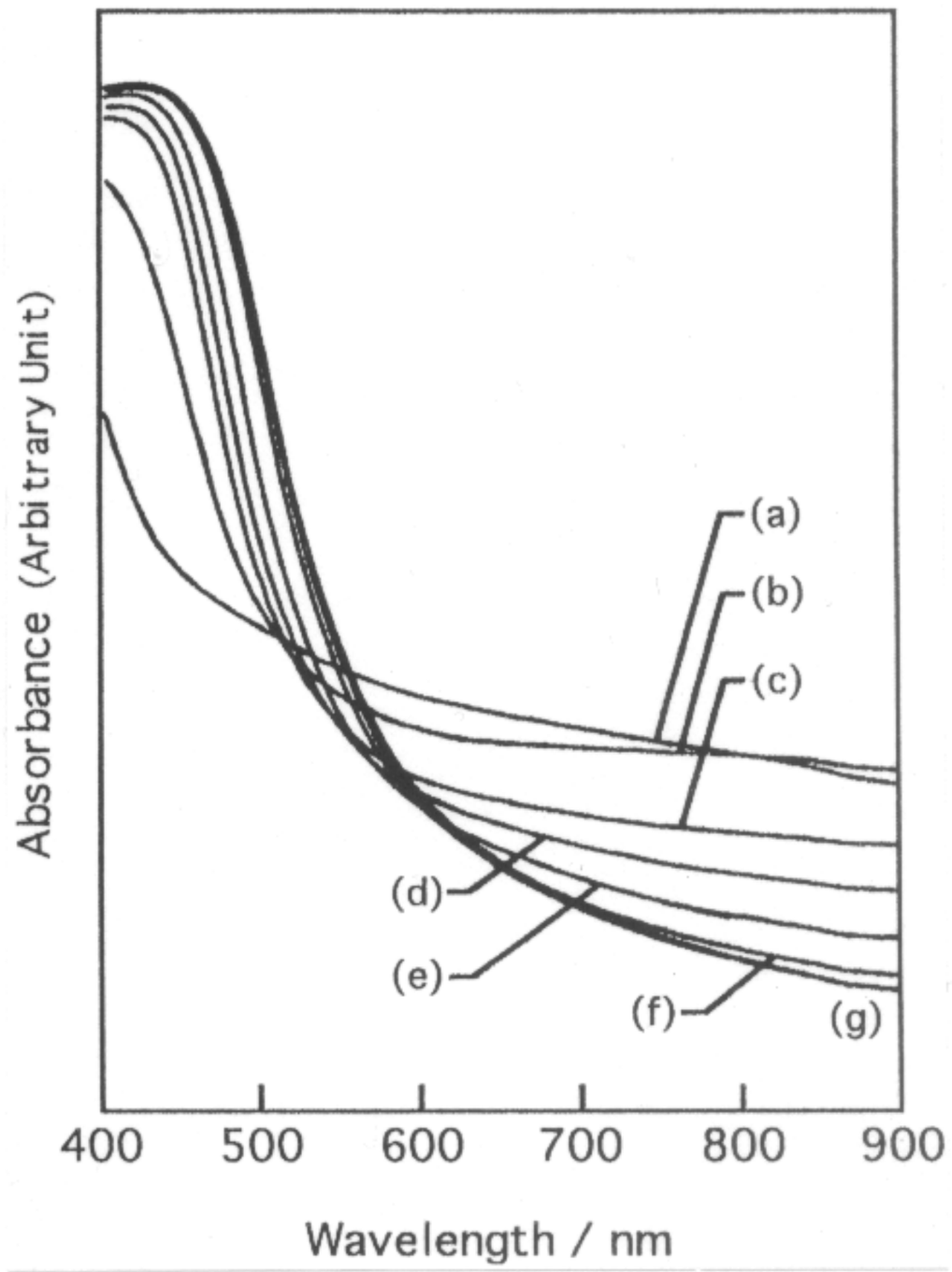


Fig. 1 Optical absorption spectrum of the $V_2O_5$ film *in situ* at various electrode potentials: (a) -0.6; (b) -0.4; (c) -0.2; (d) 0; (e) +0.2; (f) +0.4; (g) +0.8V *vs*. $Ag^+/Ag$.

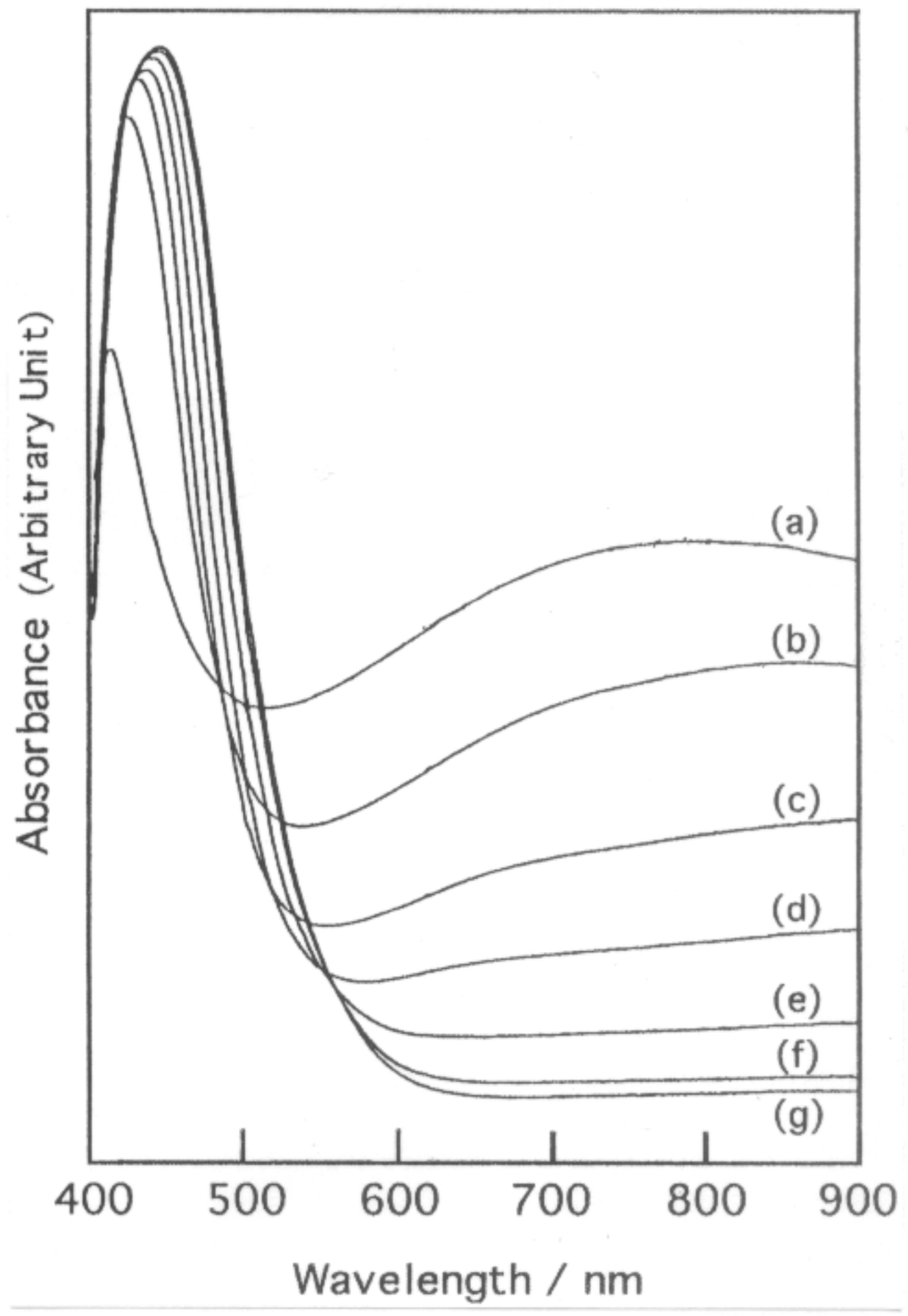


Fig. 2 Optical absorption spectrum of the PPTA-$V_2O_5$ film *in situ* at various electrode potentials: (a) -0.6; (b) -0.4; (c) -0.2; (d) 0; (e) +0.2; (f) +0.4; (g) +0.8V *vs*. $Ag^+/Ag$.